THE BUILT ENVIRONMENT AND CHILDREN'S HEALTH

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Synopsis for Table of Contents:

The built environment embraces a wide range of concepts, from the design and integrity of housing, to land-use and urban planning. A high quality environment is essential for children to achieve optimal health and development. Building and land-use policies, including the quality and design of a child's physical environment, can cause or prevent illness, disability and injury, and degrade or preserve natural resources. Though many common pediatric conditions such as obesity, asthma, and lead poisoning as well as injuries, are associated with risk factors within a child's built environment this issue has received little attention from researchers or policymakers. This new field is ripe for etiologic and prevention research, and we need pediatric advocates to speak out for children's needs within this arena.

The quality and design of a child's physical environment can cause or prevent illness, disability and injury; therefore a high-quality environment is essential for children to achieve optimal health and development. While pediatricians are accustomed to thinking about health hazards from toxic exposures, much less attention has been given to the potential for adverse effects from "built environments" such as poor-quality housing and haphazard land-use, transportation, and community planning. In fact, children spend little time in natural environments compared to the time they spend indoors and in neighborhoods.

As children grow and mature, the scope of their environment predictably expands from the womb to the wider community to the broadest reach of the planet. The child's built environment is a central factor in this progression. Both known and newly emerging diseases are linked to risk factors within the built environment, including injuries, lead poisoning, and the current epidemics of asthma and obesity. Building and land-use policies can either undermine or promote safety, health and optimal development while simultaneously preserving future resources. This newly evolving field is ripe for future research. We urgently need pediatric advocates who can effectively speak out for children's needs within this broad arena. This chapter will review and summarize the negative and positive impact of the built environment on children's health.

OBESITY, ASTHMA, AND INJURY

Childhood obesity and asthma have increased dramatically in the last two decades (21, 2692) and are exacerbated by factors in the modern built environment. In addition, recent reductions in childhood injury are directly linked to the introduction of safety measures to housing construction and community and roadway planning. This section summarizes the trends in occurrence of these diseases and their links to risk factors in the built environment.

Obesity is an important predictor of pediatric hypertension and increases risk of common and disabling adult conditions such as coronary artery disease, hypertension, dyslipidemia, osteoarthritis, diabetes mellitus, and some cancers (72,80). From 1963 through 1991, the prevalence of obesity among children and adolescents increased steadily, with most of the increase occurring since 1976 (23,30). The last report from the National Health and Nutrition Examination Survey (NHANES), taken during the period 1988 through 1994, found that approximately 14% of children and 12% of adolescents were overweight (30).

Overweight occurs when food energy intake exceeds energy expenditure (47,53). The causes of the current obesity epidemic are complex, with inadequate physical activity being a critical factor (47,53). Physical activity declines when children lack adequate opportunity to exercise during or after school and when they rely on private automobile transportation rather than walking, biking or mass transit (32,54). Community and neighborhood design can either promote or hinder physical activity (20). Design and program strategies such as building sidewalks to encourage walking (32.54), developing and promoting walk-to-school programs (20, 32), and reducing traffic speeds all are ways to promote physical activity (20, 32, 77, 93).

Asthma is now the most common chronic childhood disease, occurring in approximately 54 of every 1000 children (21). From 1980 through 1996, childhood asthma increased dramatically, by approximately 5% per year (14, 16, 26). The etiology of asthma is complex and multifactorial; risk factors include genetic predisposition as well as exposure to environmental and infectious triggers. Environmental triggers within the home include allergens from mold, dust mites, cockroaches, and pets (60, 61, 65, 69, 83, 90, 91, 101, 105); indoor air pollutants such as tobacco smoke (42, 66, 102); volatile organic compounds (104); and combustion by-products (51,70, 78). Outdoor triggers include respiratory irritant air pollutants (36) such as ground-level ozone (11, 48, 103) and respirable particulate matter (5, 39) and allergens such as soy dust (2).

Research strongly suggests that controlling such environmental asthma triggers as allergens and air pollutants would substantially reduce childhood asthma. For example, Lanphear and colleagues recently estimated that elimination of residential risk factors for asthma would reduce 39% of asthma diagnoses in the United States, at a cost savings of \$402 million (57). Friedman and colleagues evaluated whether asthma events were reduced during the 1996 Olympic Games in Atlanta, Georgia, when Atlanta instituted a plan to reduce automobile congestion through widespread use of public transportation (45, 67). These efforts lead to a 22% decline in traffic counts; a 28% decline in daily ozone concentrations; and most importantly, a 41 % decrease in asthma acute-care events.

Pediatric injuries are the leading cause of death for children aged 1 to 21 years (19). Annually, 20% to 25% of all children sustain an injury severe enough to require medical attention, missed school, or bed rest (17). Each type of injury has a particular demographic pattern and set of risk and preventive factors. Pedestrian injuries, falls from windows, carbon monoxide poisoning, and burns all are preventable with known interventions.

Children are at risk for pedestrian injuries (22,27,82). In 1999 children aged 15 years and younger comprised 23 % of the population but accounted for 30 % of nonfatal pedestrian injuries and 11% of all pedestrian

fatalities (19). Pedestrian injuries have decreased in recent years; the reasons for this decrease are unclear. Less walking might be one explanation; a recent British study found that children walking unaccompanied to school declined from 80% in 1971 to 9% in 1990 (50, 86). Environmental interventions to reduce pedestrian injuries include efforts to reduce traffic speed and volume, routing traffic away from neighborhoods, and building walkways and sidewalks (84, 85).

Falls, carbon monoxide poisoning, and burns are common injuries that occur in the home (18, 82). In 1991, 40% of fall fatalities occurred in children younger than 5 years of age; death usually occurs after falls from three or more stories (3, 33). Window barriers are a highly effective method of preventing toddler falls from windows; New York City has virtually eliminated window falls by using such barriers (89). Carbon monoxide poisoning is the cause of nearly all deaths from gas or vapor poisoning (28). Among them, about one-third are due to carbon monoxide emissions from home heating devices, which is preventable with adequate ventilation of heating equipment and use of smoke and carbon monoxide detectors. Among children, residential fire deaths are greatest among children younger than 5 years of age (18). Residential fire deaths are more common in winter months due to Christmas trees and seasonal use of portable heaters, fireplaces, and chimneys (18). Research indicates that fatal fire injury can be reduced by 71% through the use of smoke detectors (87). In addition, installation of residential sprinkler systems would prevent nearly all fire deaths and injuries (37).

HOME AND SCHOOL

Faulty construction or neglected maintenance is the primary cause of structural hazards in homes and schools. Faulty construction leads to building defects that increase the likelihood of structural hazards and fires, which in turn increase the risk of falls, burns, and other injuries. These defects also lead to inadequate ventilation and moisture accumulation; both factors raise the levels of asthma triggers in the home (38, 52). Poor ventilation, especially of tightly sealed homes, can lead to the buildup of combustion by-products (such as carbon monoxide and nitrogen oxide compounds), especially when wood-burning stoves, gas cooking stoves or fuel space heaters are used for heating (31, 70, 78). In addition, synthetic components of building materials (for example, synthetic carpet and pressed wood) may emit toxic or respiratory irritant chemicals such as formaldehyde (56, 63, 68). High moisture levels promote overgrowth of mold and attract rodents and such insect pests as cockroaches.

Enactment and enforcement of building codes can prevent structural defects from faulty construction.

These efforts include establishing legal construction standards, issuing construction permits, and conducting inspections during the building process. Building codes and residential or school siting requirements must be tailored to the needs of local communities, for example, by incorporating earthquake reinforcement strategies in areas that have active fault lines, planning for periodic flooding in flood-prone areas, or prohibiting construction near facilities that emit hazardous pollutants such as lead. Government licensing agencies and professional organizations also require building and construction professionals to meet specific education and training requirements to obtain and renew their license. Prior to the 1990s, these systems did not address the management of lead paint hazards but did assure prevention of major structural defects in housing construction and renovation.

Low-income children are more likely to be exposed to structural hazards in the home and are more likely to have diseases such as lead poisoning and asthma (14, 35). And among poor children, African-American children are more likely to live in substandard housing conditions than are whites. For example, in a study of predictors of lead poisoning among children living in hazardous housing, African-American children were significantly more likely to live in rental housing of poorer condition and with higher dust lead levels than were whites (58, 59).

A more common cause of structural hazards in the home is inadequate or deferred property maintenance, which is common in low-income rental properties. As with faulty construction, poor maintenance can lead to water leakage, structural damage, inadequate heating and lighting, and electrical hazards. Over the long term, water leaks cause accumulation of moisture and further structural damage. This sequence of events leads to overgrowth of mold, degradation of hazardous materials that contain of asbestos or lead, reduction of indoor air quality, and infestation by rodents and insects. Exposure to these factors has been linked to asthma, injury from burns or falls, and carbon monoxide or lead poisoning in children. Exposure to respirable asbestos fibers increases the risk of lung cancer and mesothelioma in later life (1).

Along with the home, the structural condition of school and childcare settings can pose similar health risks as well. For example, a 1995 study by the United States General Accounting Office found the nation's schools to be in structural disarray (100). In that survey, one-third of schools needed extensive repair or replacement; among the remaining two-thirds that were in relatively good condition, about 60 % of one major building component needed to be repaired, overhauled or replaced. Common problems were damaged framing, floors and foundations; defective

heating, cooling and ventilation systems; and leaking roofs. Nationwide, approximately 14 million students attended these substandard schools.

A 1999 convenience sample survey of 39 New York City public schools revealed similar findings (49). These schools had hazardous conditions such as inadequate heat, or lack of fire extinguishers in 30% of buildings, and unclean bathrooms in 45% of facilities. Since many of the nation's schools were built when leaded paint was widely used, lead hazards are common in school facilities as well. For example, a 1998 school survey by the California Department of Health Services found that 78% of California's public schools contained lead containing paint, 38% had flaking or peeling lead containing paint that posed a potential lead hazard, and 18% had water-lead levels that exceeded the United States Environmental Protection Agency (EPA) drinking water standard (13).

Efforts to control construction and environmental hazards in public schools have been hampered by inadequate funding for school maintenance and by the failure of local school boards to prioritize this issue on par with pedagogic concerns. In many parts of the United States, efforts to address construction hazards in public schools lack adequate resources to develop and sustain comprehensive programs to assure clean, attractive, safe, and developmentally appropriate facilities.

THE EXAMPLE OF CHILDHOOD LEAD POISONING

No children's environmental health problem is more closely associated with the condition of the home environment than childhood lead poisoning. Over the last 30 years, there has been a sustained effort to eliminate this disease. This effort is a model for broader programs to address the child health consequences of substandard housing. In this section, we summarize the epidemiology of childhood lead poisoning and the recent efforts to eliminate it.

Lead is a systemic toxicant to both children and adults and causes a range of health problems depending on the duration and amount of exposure. Moderate levels of lead exposure in childhood have been linked to reduced intelligence (6,7), learning disabilities (7, 75, 76), behavioral disorders (74, 75), school failure (76), microcytic anemia (34), dental caries (71), and reduced growth (88). Higher levels of exposure cause acute cerebral edema and seizures, with permanent neurologic segulae being a common consequence (12, 24). There is no known safe level of

exposure to lead. Throughout the last century, childhood lead poisoning was the most common, though entirely preventable, pediatric environmental disease.

In the last quarter-century childhood lead poisoning declined dramatically as common sources of lead exposure such as leaded gasoline were eliminated or reduced. From 1976 through 1994, the prevalence of elevated blood lead levels [10 micrograms lead per deciliter whole blood (µg/dL) or more] among children aged 1 to 5 years dropped from 88.2% to 4.4% (10, 29, 79). As childhood lead poisoning has declined, its frequency became more varied across family income, geographic area, and ethnicity, and lead poisoning became concentrated in poor, African-American children living in substandard housing in inner-city neighborhoods (29). These children now have the highest and most sustained levels of lead exposure, because they are more likely to live in poorly maintained dilapidated rental housing where they are exposed to high levels of leaded paint dust throughout their early years (58, 59).

In the early 1990's, the need for a new and expanded effort to identify and contain lead hazards in housing became clear. In response, the federal Centers for Disease Control and Prevention (CDC) launched a 20-year strategic plan to eliminate childhood lead poisoning by controlling lead hazards in housing (25). In addition, CDC lowered the level of lead in blood considered elevated to the current level of 10 µg/dL or more, and recommended and supported expanded blood lead screening of children at ages 1 and 2 years (24).

A dramatic expansion in lead poisoning prevention efforts followed. This expansion had two major components: one that focused on identifying lead poisoning in children; and one that focused on identifying and controlling lead hazards in housing. The first step in building this program was establishing a legal framework.

Congress, state legislatures, and local communities passed a series of laws that required health and housing programs to care for lead-poisoned children and to address lead hazards in housing. For example, in 1992, Congress enacted the Residential Lead-Based Paint Hazard Reduction Act as Title X of the Housing and Community Development Act, which led to extensive research, regulatory, and program efforts.

Title X had a wide-ranging impact on lead-hazard control. It required EPA to set health-based regulatory standards for levels of lead in paint, dust, and soil; to identify cost-effective methods for identifying and controlling lead hazards in housing; and to establish a new program for training and certifying lead-hazard control professionals (41). As a result, a new workforce of trained construction professionals emerged to inspect and manage lead hazards in housing. Title X also required notification of new buyers or renters of pre-1978 housing that lead hazards

may be present. Implementation of Title X resulted in expanded efforts to identify and control lead hazards in federal low-income housing through federal and local housing programs (98).

These efforts broke a logjam in lead hazard control. Prior to 1990, complete removal of all lead paint in a home was believed to be the only effective way to eliminate childhood lead poisoning, an approach that was prohibitively expensive (25). Research by Farfel and others demonstrated that limited and low-cost housing interventions (such as replacing windows and making floors smooth and cleanable), coupled with ongoing efforts to prevent lead paint from deteriorating into dust through specific cleaning and maintenance practices, could substantially reduce housing-based lead hazards over the short and long term (43, 44, 64, 73, 97). In response to these findings and to Title X, the United States Department of Housing and Urban Development (HUD) required its low-income housing programs to identify and control lead hazards within their units (and provided increased funding to pay for the work (95). In 2000 alone, HUD awarded lead-hazard control grants to states and locales that totaled \$105 million (96).

In 2000, the United States Department of Health and Human Services reaffirmed its goal of eliminating childhood lead poisoning by 2010 (81). Recent analysis of data from the 1996 - 1999 NHANES and state blood lead surveillance programs, found that though children's blood lead levels have continued to decline, geographic areas of high risk persist (15).

Eliminating childhood lead poisoning by 2010 will succeed only with continued support of lead-hazard control programs, along with strategic program shifts over time. In the next decade, these programs must transformation themselves by shifting their focus from screening children for lead to screening and controlling housing for lead. Essential to the success of these efforts is developing a method to conduct housing and neighborhood lead assessments that identifies the most hazardous housing and ensures that it receives timely repair.

Childhood lead poisoning prevention programs will also need to expand their focus. The presence and degree of lead hazards in housing is tied to the structural integrity or deterioration of the home; controlling lead hazards requires controlling underlying structural defects (64). Lead programs must become comprehensive programs to control housing-based health hazards. This transformation will require a strategically staged and sustained effort, with the highest level of intervention for the most hazardous housing and a more modest approach for homes with few or potential hazards.

Preventing lead poisoning by replacing or upgrading housing provides an unprecedented opportunity to bring the nation's worst housing stock up to legal building code. Leaded paint becomes hazardous to children when housing is allowed to deteriorate through deferred maintenance. In addition, lead hazards can only be controlled when the underlying housing defects that damaged the paint are repaired.

Recently, HUD has broadened its focus from lead-hazard control to the healthy home (99). The purpose of this approach is to comprehensively correct all structural defects and install safety protections when lead abatement is performed. For example, when a crew is brought in to stabilize leaded paint, they also install energy-efficient windows, repair leaks, ensure basic structural integrity of the home, control for pests, and check for and install window barriers and detectors for smoke and carbon monoxide. Though this holistic approach to correcting dilapidated housing may provide additional health benefits, it requires definition and research to assess its effectiveness before it becomes standard housing practice.

FROM HEALTHY HOME TO HEALTHY COMMUNITY

Quality land-use planning and urban design protects human health and quality of life and preserves essential natural resources such as open space, forests and clean drinking-water supplies. With the projected doubling of the U.S. population over the next century (4), protection of water sources, both underground and surface water (lakes and rivers), is no longer solely an aesthetic issue but a critical health protection need as well.

Forests sustain the planet because they provide shade and cooling and contribute oxygen to the atmosphere. When forestland is destroyed, rapid runoff of rainwater introduces silt, road wastes, and toxic materials to source water (4). Poorly maintained private septic systems cause groundwater contamination that can last generations (46). Ever-widening highways, asphalt paving, and treeless urban areas cause an increase in the ambient temperature and "heat islands" (9). In summer, when temperatures rise these heat islands develop large geographic areas with sustained high temperatures, increasing risk of heat stroke among residents (9) as well as having indirect effects. For example, this sustained heat catalyzes chemical reactions among various air pollutants and ground-level ozone formation soars. Sustained periods of high ground-level ozone pollution has been linked to an increase in asthma attacks (48, 11, 103).

In contrast, a healthy community is not just one with excellent medical care: it is one with an environment that encourages physical activity and social contact and provides healthy air and landscapes. Today's cities sprawl into forest and farmland with ever widening roadways but no sidewalks or bicycle routes (4). With their vast asphalt parking areas and treeless streets, these cities coddle the automobile while denying children the opportunity to experience the wonder and joy of the natural world. What child can be allowed independent exploration in cities experienced as dangerous and lacking parks and sidewalks? Parents exhausted by long commutes and endless traffic can scarcely cope with their own needs after long days; consequently, they find the inevitable demands by hungry and tired children more exhausting than refreshing. In this setting, virtually every task requires a car, even a trip to school, church or the library, and the quality time for parents and their children is reduced to brief conversations in the car. The developmental and psychological effects of barren and commercialized landscapes need to be further examined.

RESEARCH NEEDS

There are still few researchers documenting the damage to health of bad neighborhood design. For example, while we know that exercise helps to control weight and people walk more in cities designed to encourage walking, there is as yet no evidence that evaluates whether approaches to urban design that promote walking reduces overweight. Only limited research has evaluated whether transportation planning and efforts to reduce automobile use actually lowers exacerbations of asthma. The scope of activities and health benefits of healthy home interventions still needs further definition and evaluation of effectiveness. Connections between urban planning and mental health still need to be defined. This new research field is wide open.

SUSTAINING HEALTHY COMMUNITIES INTO THE FUTURE

When considering the range of issues encompassed by the interaction of children and their environment, two worlds come in to play: the very tangible world the child is touching, tasting, and experiencing daily and the future world into which the child is growing. Assuring that the child's proximate world is safe is straightforward through such actions as covering electrical outlets and putting toxic chemicals out of reach.

This same mindfulness must be brought to the child's whole world, right from the snug confines of her small room to the edges of her crowded planet. Issues that seem predetermined—how we build over forests, open space and farm land; protect source water and ensure safe drinking water; lay out housing subdivisions, transport people and goods; build schools; and ensure walkable neighborhoods—are children's environmental health issues as well. Many of these issues seem too large for individual parents or families or neighborhoods to grapple with, but communities have effectively joined together to demand good public transit, bicycle and walking routes, and parks (4). Once these amenities are put in place, no community is willing to give them up. Strong spokespersons from the health community—especially those who can represent the current and future needs of children—along with housing, police, faith and other leaders must be involved in such efforts as well. Every child, developed world or developing world, urban or rural, financially secure or poor, has a right to a healthy environment, and the built environment is the one in which children spend most of their young lives.

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